

# Northeastern Forest Experiment Station

Upper Darby, Pa.

## QUARTERLY REPORT ON

## FOREST INFLUENCES AND FLOOD CONTROL SURVEYS

January 1, 1952



### FLOOD CONTROL SURVEYS

by Norman R. Tripp

The final quarter of 1951 saw work progressing steadily on our two principal projects—completion of pending reports and work on the NENYIAC Resources Survey.

It has also been a period of considerable discussion among ourselves and with SCS people about the form and content of past and future flood control reports. In view of the Bureau of the Budget and Committee on Public Works comments, a new approach is indicated. We have reached several conclusions as the result of these discussions.

First, we feel that we have been overemphasizing control of river stage and selling ourselves short on reduction of erosion damage to land. Reduction of high river stages and their attendant damages is important and should continue to receive full attention but it is by no means the whole story of damage from excess runoff and sedimentation. In many watersheds it is only a small portion of the total damage.

Secondly, we think that every benefit that results from the reduction of excess runoff and sedimentation (wherever they occur) should be shown as such. This new heading in the reports would replace the old one of "Benefits from the Reduction of Flood Damage." The term "flood damage" carries a connotation of high river stage and as such is much too restrictive to apply to a land program. "Benefits from Runoff and Water-flow Retardation and Soil Erosion Prevention" would include such things as prevention of on-site land damage by soil erosion; reduction of highway maintenance costs due to the scouring and silting of ditches, undercutting of fill slopes, deposition of sediment (from any source) on road surfaces,

etc.; reduction of land and crop damage resulting from deposition of eroded material from any source; reduction in loss of agricultural land values as the result of gullying which increases the difficulty or prevents machine operation; and other similar items as well as the benefits from reduction in river stage which we have customarily shown.

For some of us this will be a considerable departure from past practice. However, we feel that such a procedure is desirable for several reasons. First, as we read our charter in the 1936 Flood Control Act, this is what we should have been doing all along. Second, it should serve to remove the source of a good deal of the friction between the Department and other agencies who are concerned only with flood control on the rivers since in most cases a large part of the benefit will come from areas with which they do not deal. Third, it puts in proper perspective the true value of our recommended programs in the interest of "runoff and water-flow retardation and soil erosion prevention."

We are attempting to spread our discussion out service-wide and will be very much interested in any ideas or comments that anyone has to offer.

#### STATUS OF FLOOD CONTROL SURVEY REPORTS

Connecticut River.--In Washington for final approval.

Merrimack River.--Waiting for comments on review draft.

Salt River.--Comments received--final draft in process.

Allegheny River.--First draft in process.

Upper Susquehanna and Monongahela Rivers.--No further progress.

#### NE-NYIAC--RESOURCES SURVEY

Routine compilation work on Hydrology, Land Use, and Damage Appraisal is progressing steadily. The job of revising land-use data to conform with the 1950 census is practically finished.

Preliminary reconnaissance has been finished on the local damage centers for the entire NE-NYIAC area. Of approximately 825 locations reported about 50 were found to have some possibility for local protection programs of the size and type that might be recommended by the

Department of Agriculture. These will need further and more detailed study to determine whether such programs can be justified. Reports are being prepared jointly by the Department of Agriculture and the Corps of Engineers on each location visited on the reconnaissance. In the near future these reports will be circulated to the states and other agencies for review and comment.

## FOREST INFLUENCES

### DELAWARE BASIN RESEARCH CENTER

by the Delaware Basin Staff

This quarter marks the beginning of the fourth hydrologic year in the process of calibrating the Dilldown watershed. Field measurements are continuing as before except in cases where analysis has shown that additional measurements are desirable. Tabulations and compilations fell in arrears during the early part of the quarter because of the absence of Harry Price, our hard working statistical clerk. Since his recovery from the Upper Darby office, Harry has completed the data for the past hydrologic year and has this year's data nearly up to date as this is written.

The weather has been particularly inclement during the quarter. Rain and snow entirely nullified the fall fire season in the Pocono mountains but it also hampered the anticipated field work to a considerable extent.

#### Water Relations

Hydrologic year 1950-1951 was an interesting departure from the two previous years which had almost normal rainfall. During the year, 60 inches of precipitation was received by the Dilldown watershed, 15 inches in excess of apparent normal annual precipitation of 45 inches.

The following tabulation shows the effect of the increased rainfall on streamflow and ground water:

	Hydrologic Year		
	<u>1948-49</u>	<u>1949-50</u>	<u>1950-51</u>
Precipitation - inches	48.92	45.08	59.94
Streamflow - inches over the watershed	25.41	26.66	36.43
Water loss - percent	48	41	39
Ground water - average height above mean sea level	1885.3	1885.2	1886.3

As pointed out a year ago, the greater water loss in 1948-49 was due mainly to distribution of rainfall; a high proportion of the total precipitation fell during the summer months when evapo-transpiration losses were heaviest. During this period, little precipitated water

reaches ground water and thus streamflow from the ground water reservoir was not increased by the heavy summer precipitation.

This year, the distribution was essentially the same as in year 1949-50, resulting in about the same proportion of water loss. It is noteworthy that ground water averaged one foot higher than in previous years--an important consideration.

The shallow wells dug a year ago have given us information on the perched water table in the swampy area in the upper part of the watershed. The well which reaches into ground water and is sealed off from the perched water table rises and falls in a much different pattern from the shallower well in the perched water table. During the dry summer months, its level dropped in accordance with the levels in the drilled wells and fell considerably lower than the companion dug well. An interesting feature of the ground water well sealed from the perched water table is that its level rises considerably above the ground surface in the winter period when ground-water levels are high. This artesian effect is added evidence of the impervious layer causing the perched water table. Up to now, we have not been able to measure the height to which this level rises, as it overflows the well casing. We have been attempting to extend the casing but have not yet been successful.

### Vegetation Survey

Following the layout of the 26 survey lines, the necessary maps and forms were processed, and the field work on the vegetative survey was begun. The plan as written was found to be workable with no change. It was also found that the survey could best be done during fall, winter, and spring, while the deciduous vegetation is not in leaf. No difficulty was experienced in identifying species, even from a distance, while visibility and ease of movement were much increased during the dormant seasons. Considerable aid in the field work has been provided by Gene McNamara, research forester for the Pennsylvania Department of Forests and Waters.

Unfortunately, the inclement weather cancelled out much of the field time anticipated for the survey. It is hoped that the weather during the latter part of the winter and early spring will allow us to complete the survey.

### Interception

Measurements of the amount of rainfall intercepted by the present vegetative cover of the Dilldown watershed have been carried through the second summer.

The three stations installed in 1950 were reactivated without change and two additional stations were added. Another stemflow installation was also completed this year in our small area of high forest.

Partial analysis of the data has been completed to date. Very close correlations have been found between thru-fall and size of storm and between stemflow and size of storm. The relationships are of such high significance that it appears no other variables need be taken into account.

Preliminary equations which may be subject to revision are as follows:

For scrub oak of medium height and density,

$$I.L = 0.043 P + 0.008$$

For high forest of mixed hardwoods and conifers,

$$I.L = 0.15 P + 0.015$$

in which I.L. = net interception loss in inches of precipitation; P = total storm precipitation in inches.

Stemflow from the larger trees was a very slight amount, according to our data. It is represented by the equation:

$$S.F. = 0.02 P - 0.002$$

On the other hand, stemflow from rhododendron in the open amounts to:

$$S.F. = 0.22 P - 0.007,$$

about ten times as much as that from the tree growth.

#### Soil Freezing Studies

Last winter, soil freezing observations were made at seven different areas in the Northeast. At each area observations were made on soils under different types of land use. Additional observations will be made this winter. Much of the Center's effort was devoted to instructing the new frost observers in the methods of frost and snow measurement, in order to obtain comparable results from all Centers.

#### Soil Moisture Studies

Jerry O'Brien devoted most of his time to assembling all the available soil moisture and climatic data in a form that would facilitate the analysis of soil moisture losses. For the time being, we are analyzing soil moisture losses that occur when the soil is at or below field capacity. This analysis is far from completion. However, we can, with fair assurance, say that soil moisture losses can be related to saturation deficit. We are now testing the relationship of soil moisture losses to soil moisture content and air temperature.

We continued calibrating, in the laboratory, soil samples that were taken from the deeper soil horizons (down to four foot depth). Now we are engaged in the necessary calculations required to reduce the data to the form of a calibration curve.

#### Miscellaneous

Prof. Jenkins (of Lehigh University) has been using data from selected storms at Dilldown to conduct part of his course in hydrology. For the particular dates in question, we have given him all of our available data on precipitation interception, soil moisture, ground water, stream-flow and the climatic elements.

In October, Professor Jenkins and his class in conservation visited the Dilldown watershed. Reigner and McNamara conducted them on a tour visiting the planting areas and the various installations.

A group of U. S. Geological Survey personnel visited the Center in order to study our soil moisture study techniques. The group included G. S. Hilton, Sol Lang, J. M. Birdsall, C. H. Gaum and E. C. Rhodehamel from the Trenton, N. J. office and Irwin Remson, Joe Higgins, and Sid Fox from Seabrook Farms, N. J., where intensive research is being undertaken on ground water accretion.

The annual meeting of Incodel (Interstate Commission on the Delaware) was held this year at Pocono Manor, Pa. Center personnel attended this meeting.

## FERNOW EXPERIMENTAL FOREST

by Weitzman and Trimble

### SKID ROAD EROSION

#### Field Test & Area No. 2

The Quarterly Report for the period April to June, 1951, gave some preliminary results on soil lost from logging skid roads. On one skid road, water bars had been installed at two chain intervals. The other road did not receive any drainage provisions. It was merely abandoned after logging. (All skidding was done with an arch behind a tractor. This arch lifted the front end of the logs off the skid road and reduced erosion).

Since that report two additional remeasurements have been made. The following table summarizes the data:

Table 1.--Average soil loss in cubic feet per  
100 linear feet of skid road

Period	Road With Bars	Road Without Bars	Difference
After logging			
March-April-May 1951	-55	-129	-74
June-July-Aug. 1951	-50	+ 10	+60
Sept.-Oct.-Nov. 1951	-11	- 41	-30

This table brings out one striking observation, the reversal of erosion trends for the 2 roads during the period June to August, inclusive.

Immediately after logging, the water diversion bars were installed on one road. The reduced erosion on the barred skid road (from March to May) may be a sign of the effectiveness of the bars.

However, during the period June to August, the road with the bars showed the greater soil loss. The cause of this reversal was quite obvious in the field. The roads which received no treatment were covered with a heavy volunteer growth of weeds, herbaceous species and grasses while the road with bars developed only a scanty and spotty ground cover.

To date, the reason why one road was seeded naturally and the other not has not been determined. All factors such as soil, exposure and location are comparable on all roads. This study does seem to illustrate, however, the importance of vegetation as a factor in reducing skid road erosion.

After the growing period, when the annual vegetation died down, the expected erosion trend was found; erosion from the unbarred roads was greater again for the period September to November.

Observations will be continued to complete the growing cycle at least once.

#### FORMULA DETERMINATIONS

Another approach to determining how close water diversion bars should be placed on skid roads is mathematical; through use of formula. By computing the theoretical spacing and then checking in the field, it was hoped that an adjustment could be made for local conditions.

The following table gives acceptable distances between bars as computed by an adaptation of Mannings' formula:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

V = velocity in ft. per sec.

R = hydraulic radius, feet,

=  $\frac{\text{area of section}}{\text{wetted perimeter}}$

S = grade, ft. per ft.

n = roughness coefficient

Table 2.--Computed maximum spacing between bars

<u>Road Grade</u> (percent)	<u>Maximum distance between water bars</u> (feet)
2	250
5	135
10	80
15	60
20	45
25	40
30	35
40	30
50	25

These values are based on a rainfall intensity of 1.0 inches per hour and a velocity of 0.50 feet per second.

Thus far these mathematical distances have not been checked by field observations. Preliminary indications are that there are so many variables which are not considered in the formula that the mathematical distance will have to be adjusted based on field data collected. Variables such as microtopography, volunteer vegetation and rainfall pattern are the most obvious.

#### INFLUENCE OF A FOREST CANOPY ON RAINFALL INTENSITIES

A study to determine the effect of a well stocked hardwood forest on ground rainfall intensities is under way. Although numerous studies have been made which show the effect of a forest canopy in reducing the total amount of ground rainfall, insufficient data exists to show the effect of a forest canopy on the intensity of rainfall. Thus, a gap exists in our knowledge of the hydrologic effect of forests on runoff and erosion.

Comparisons are being made to show the difference between intensities under the forest canopy at several randomly selected spots and in the nearby open area. Comparisons will be made separately for summer and winter conditions to show the effect of the leaves.

An attempt will be made to stratify intensity differences between the open and under the woodland by storm characteristics. Such factors as storm size and rains of different intensities will be related to these differences.

Measurements to date indicate that a forest canopy will reduce the intensity of rainfall reaching the forest floor. In the summer rainfall intensities average appreciably higher in the open. As would be expected, the differences between intensities in the open and under canopy in the winter are less than in the summer.

### Flood and Erosion Damage to Forest Lands

This is a controversial subject. Below are statements from literature:

Kittredge says, "Erosion tends to increase with increase in degree of exposure of soil surface as determined by the character and density of vegetation. Disturbance of the vegetation and forest floor accelerates erosion. The chief causes of abnormal or accelerated erosion are, dis-  
burbance or destruction of the cover by fire, overgrazing, land clear-  
ing, improper cultivation, abandonment, construction work, logging,  
hydraulic mining, smelter fumes, and changing stream channels. Fires  
or other agencies that destroy most of the vegetation and forest floor increase the discharge of eroded material by 10 to 6,000 times."

Howard Lull summarizing the work of Zon, Wilm, and Kittredge says "Re-  
moval of forest cover by reducing interception and transpiration losses,  
generally results in increased runoff. Removal of forest cover when  
accompanied by baring the soil, generally decreases infiltration and  
increases overland flow, soil erosion and sediment loads. Maintenance  
of the natural forest cover will keep runoff and sediment loads within  
normal limits and restoration of a depleted forest cover may in time  
restore runoff and sedimentation rates to normal."

Wilde says, "Cuttings exert great influence upon composition of forest  
soil. With very few exceptions clear cutting leads to a general de-  
terioration of soil fertility. Light cutting is practiced on steep  
slopes to prevent rapid runoff and erosion. Moderate cuttings should  
not decrease soil fertility. Aside from fire hazard, burning the  
forest floor is objectionable because it results in a total loss of  
the most valuable fertilizer ingredient, nitrogen, moreover, the  
released bases are subject to a rapid leaching in the absence of  
organic colloids.

"Logging and forest fire may temporarily change the natural distribution  
of tree species. The forest cover of cut-over or burned-over areas  
rarely consists of the same species that previously dominated the area.  
Logging or fire is followed by the development of temporary stands of  
so-called pioneer species. These pioneer species are usually light  
demanding; they have low nutrient requirements and can withstand frost  
and endure sunscald. This process is called local forest succession.

"The general movement of forest toward the climax is closely related to the gradual changes which take place in the soil profile. Soils are subject to progressive weathering, and in the long run tend to increase their colloidal content and waterholding capacity. Simultaneously, the xerophytic species of light soils are gradually replaced by mesophytic species of heavier or moister soils. The accumulation of humus and podzolization of the soil have a similar effect, since both of these processes tend to increase the waterholding capacity of the soil.

"Forest soils have a potential forest growth. Removing litter, grazing, and other man caused disturbances may be responsible for poor growth on soils that otherwise have high potential productivity."

Lutz and Chandler say, "Logging has, in some places, resulted in accelerated erosion, particularly along skid roads. As a general rule, serious erosion does not occur unless fires follow or the area lies bare for a period of several years. The most obvious damage resulting from water erosion is the removal of part or all of the top soil. Erosion is frequently selective, removing from the upper soil layers their most valuable constituents. Investigations in New Jersey found that eroded material usually contained three to eight times as much organic matter and nitrogen as did uneroded soil. In addition, erosion usually results in a breakdown of soil aggregates, a reduction in field capacity, a reduction in the infiltration of water, and a decrease in activity of soil flora and fauna.

"In established forest stands erosion can best be prevented through the application of sound forest practices. This program usually involves cultural operations and harvest cuttings, but at same time requires maintenance of adequate cover to protect the soil. Injurious influences such as fire and excessive grazing must be vigorously excluded.

"Soil conditions generally are **not** static but subject to change. Foresters should avoid both the unwarranted generalization that clear cutting is usually harmful or that it is usually beneficial. If an adequate cover of vegetation fails to develop for several years after clear cutting, it is probable that deterioration of the soil will occur. Accelerated erosion and increased compactness result from destruction of soil aggregates and plugging of the noncapillary pores. Fine textured soils are far more likely to be compacted than are coarse textured soils."

Hursh found correlation of degree of erosion to tree growth says, "The Cecil series of soils are recognized as a uniformly productive major

soil series of the piedmont. Nevertheless, it was found that the average growth of pine stands varied from 0.26 cords per acre for a Cecil soil in need of extensive erosion control measures up to 1.59 cords per acre per year for a Cecil soil where only minor erosion control measures are required. Likewise for Vance and Helena soils growth in cords per acre per year ranged from 0.36 for severely eroded areas to 1.58 cords for areas slightly eroded. This demonstrates the poor site quality inherent in severely eroded and exhausted soils.

"Uncontrolled logging can seriously impair water quality by increasing stream turbidity. Turbidities as high as 3,500 parts per million were recorded from logged area during storm periods. Allowable turbidity for drinking water is 10 ppm. Average turbidity from logged area is 93.7 ppm. Compare this with 4.3 ppm from comparable unlogged area. It is believed that stream sedimentation caused by logging can be reduced to a negligible amount by more efficient access road location and maintenance, together with improved skidding techniques."

#### Discussion

Only few forest areas have missed being disturbed by logging and fire. This has deteriorated productivity of forest soils through excessive erosion, excessive leaching along with rapid release of important elements in gaseous forms.

The drainage caused by excessive runoff may be expressed in potential reduction of wood production. For example in the Allegheny, erosion of forest lands apparently is not a major problem. But there has been some accelerated erosion caused by abuse of the forest lands. Perhaps the most damage has come from the accelerated leaching which has removed the colloidal material from the soils.

This damage is difficult to evaluate and qualitative data is meagre, showing site deterioration caused by excessive leaching and erosion. However, we can evaluate the damage on the average annual growth per acre. Present forests in the watershed are producing about 30 cubic feet of wood annually. If site quality were changed these same forests would be 10 percent more productive or 3 cubic feet increase. The value of this damage is \$.05 per cubic foot or \$.15. The Allegheny watershed has 4,100,000 acres of forest land which makes a total annual damage of \$.15 times 4,100,000 or \$615,000. This, I believe, very conservative, since Hursh finds 400 to 600 percent increase in growth which may be indicative of extreme cases. Does this evaluation approach meet logic? We have no basic data to substantiate the 10 percent increase. This was an assumption. All foresters badly need this information, so let's get busy and study this problem and quit guessing.

Earl J. Rogers